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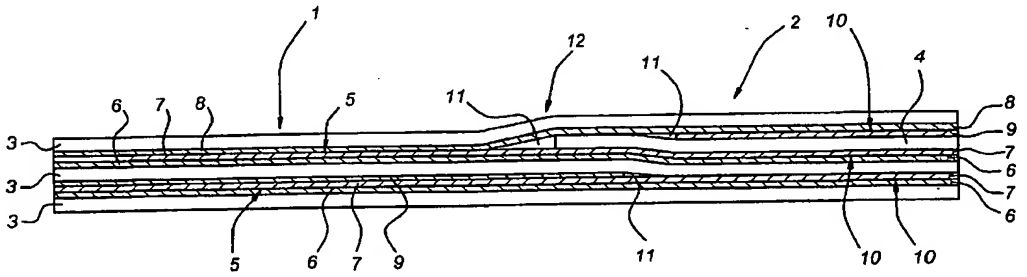
(54) Title: LAMINATED PANEL WITH DISCONTINUOUS INTERNAL LAYER



(57) Abstract: In a laminate, comprising at least one series of metal layers (3, 4) and fiber-reinforced plastic layers (6-9) which are attached to one another, at least two different series (1, 2) are provided, these series including a transition (12), and at the location of the transition (12) at least one of the internal layers (4, 9) is discontinuous and all the other layers (3, 6-8) are continuous.

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Laminated panel with discontinuous internal layer

The invention relates to a laminate, for example designed as a laminated panel, comprising at least one series of metal layers and plastic layers, which comprise fibers and are impregnated with a plastic material, attached to one another.

A laminate of this type is known from WO-A-9853989 and is used, for example, in cladding panels for aircraft. In that case, the metal layers usually consist of an aluminum alloy. The plastic layers may, for example, be composed of plastic fibers with a high modulus of elasticity and consist, for example, of aramid. The plastic material with which the fibers are impregnated may be either a thermoplastic or a thermoset.

The advantage of a laminated panel is that the strength and rigidity properties can be locally adjusted. For example, at the locations where relatively high loads occur, for example around door openings, additional layers can be included in the laminate. In this way, by means of suitable selection of the dimensions of the layers, it is possible to obtain a gradual transition between the various regions in the panel without stress concentrations being otherwise introduced.

Panels of this type were joined to one another by means of a seam or splice, in which the edges or panels of this type overlap one another. An overlap of this type, which is disclosed by NL-C 1015141, however, forms a sudden, external interruption to the continuous nature of the aircraft cladding composed of panels of this type. WO-A-9853989 has also disclosed a connection between the various layers in the panels in which a separate connecting strip (doubler) is used. A connecting strip of this type also disturbs the externally continuous character of the panels. Interruptions of this type are undesirable both for reasons of aerodynamics and of strength and rigidity.

In addition, it is known to produce the laminate as a whole in various types, with more or fewer layers, in order to create panels which are intended for zones of an aircraft, for example, which are subjected to higher or lower levels of load. For example, there are panels with four metal layers, between each of which there are sets having two plastic layers (type Glare® 3). In yet another type, three metal layers are used in combination with sets of three plastic layers (Glare® 4).

Therefore, it is an object of the invention, in a laminate, to provide a smooth transition between series of different composition. This object is achieved by the fact

that at least two different series are provided, these series including a transition, and in that at the location of the transition at least one of the internal layers is discontinuous and all the other layers are continuous. At the location of the transition between two series with different series of layers, there may be a sudden change in the thickness of the laminate, but this need not necessarily be the case.

If one or more layers are allowed to end in the interior of the laminate, it is possible to obtain a very gradual transition, in such a manner that stress concentrations and undesirable aerodynamic effects are avoided.

The laminate according to the invention can be designed in numerous different ways. For example, there may be in each case one set of at least two fiber-reinforced plastic layers between two adjacent metal layers, in which case the set is split at the end of a discontinuous metal layer, in such a manner that its plastic layers are located on either side of the discontinuous metal layer. Furthermore, at least one of the sets of fiber-reinforced plastic layers may include a discontinuous plastic layer.

The continuous nature of the majority of the metal layers and the fiber-reinforced plastic layers leads to the transition in the laminate being very gradual.

According to a preferred embodiment, on either side of the discontinuous metal layer there may be sets which have a different number of fiber-reinforced plastic layers from the sets in the region without a discontinuous metal layer. As an example, one series may comprise three metal layers, between each of which there is a set of three fiber-reinforced plastic layers, and another series may comprise four metal layers, of which three layers are continuous from the first series and of which an intermediate metal layer is discontinuous, between each of which four metal layers there are sets comprising two fiber-reinforced plastic layers, of which the sets of plastic layers on either side of the discontinuous metal layer are formed by a discontinuous plastic layer and three plastic layers, which have continued from the first series, of a first set of three plastic layers, and the second set of three plastic layers has two plastic layers which continue into the other series and one discontinuous plastic layer which is not continued into the other series. The result is a transition between laminates of the Glare® 3 and Glare® 4 types.

According to a further variant, there may be four metal layers, between each of which two plastic layers extend in one series, while in another series there are also discontinuous plastic layers, so as to form sets of three plastic layers. This variant too

forms a transition between the Glare® 3 and the Glare® 4 types.

The invention will now be explained in more detail with reference to the laminates illustrated in Figures 1-7.

Figure 1 shows a laminate according to the invention, which laminate comprises a first series 1 and a second series 2, which series 1, 2 include a transition region 12. The first series 1 comprises three metal layers 3 which are continued into the second series 2. Moreover, this second series 2 includes a discontinuous metal layer 4, which does not continue into the first series 1.

In the first series 1, two sets 5 each comprising three fiber-reinforced plastic layers 6, 7 and 8 are accommodated between the three metal layers 3. The top plastic layer 8 of the top set 5 runs over the top of the discontinuous metal layer 4, while the other two plastic layers 6, 7 of the top set 5 run underneath the discontinuous metal layer 4. A discontinuous plastic layer 9 starts at a certain distance from the edge of the discontinuous metal layer 4, in such a manner that the region between the top continuous metal layer 3 and the discontinuous metal layer 4 is substantially filled by a set 10 comprising two plastic layers 8, 9.

Between the discontinuous metal layer 4 and the continuous metal layer 3 located directly below it there is also a set 10 of two fiber-reinforced plastic layers 6, 7, both of which are continuous. The same is true of the bottom two continuous metal layers 3, which in the series 2 likewise enclose a set 10 of two discontinuous plastic layers 6, 7. The top plastic layer 9 which, in the first series 1, together with these plastic layers 6, 7 form the bottom set 5, is discontinuous and does not carry on into the second series 2.

These layers are attached to one another by means of a bonding agent, some of which can be seen at 11 in the transitions which have been defined between the discontinuous layers 4 and 9.

The series 1 is a laminate of the so-called Glare® 4 type, and the series 2 is a laminate of the so-called Glare® 3 type. This results in a very gradual transition between these two types, without stress concentrations or aerodynamically undesirable surfaces being formed.

The variant illustrated in Figure 2 shows a laminate with four continuous metal layers 3, which in the series 1 are separated by sets 10 each comprising two fiber-reinforced plastic layers 6, 7. These plastic layers 6, 7 run continuously into the series 2, where they form part of the sets 5 comprising a total of three plastic layers. In

addition to the continuous layers 6, 7, the sets 5 also include discontinuous plastic layers 9 in such a manner than each set 5 comprises three plastic layers.

Once again, bonding agent 11, by means of which the layers are glued together, can be seen at the location of the transitions between the discontinuous plastic layers. This laminate too forms a transition between the Glare® 3 type and the Glare® 4 type.

A further transition between a laminate of the Glare® 3 type and the Glare® 4 type is shown in Figure 3, cf. the series 2 and 1 in this figure. The discontinuous fiber-reinforced plastic layer 9 does not run all the way along the discontinuous metal layer 4. The region above the metal layer 4 where the discontinuous plastic layer 9 is absent is filled with the bonding agent 11. The plastic layers 6 to 9 themselves comprise fiber layers which are impregnated with a plastic bonding agent.

In the embodiment shown in Figure 4, the layers 9, which are located in the series 2, of the set 13 are both discontinuous. The spaces which remain between the top metal layer 3 and the discontinuous metal layer 4 are filled with the bonding agent 11.

The continuous fiber-reinforced plastic layers 6, 7 continue onward between the bottom metal layer 3 and the discontinuous metal layer 4 or the following section of the top metal layer 3.

In the variant shown in Figure 5, there is a plastic layer which consists entirely of the bonding agent 11, without any fiber reinforcement, located between the top metal layer 3 and the discontinuous middle metal layer 4. Between the bottom metal layer 3 and the discontinuous metal layer 4 or the adjoining part of the top metal layer 3 there is the set 10 comprising the two continuous plastic layers 6, 7 consisting of a fiber material which is impregnated with a plastic bonding agent.

The variant illustrated in Figure 6 shows a further transition between laminate of the Glare® 4 type in series 1 and laminate of the Glare® 3 type in series 2. The set 13 comprising the two discontinuous fiber-reinforced plastic layers 9 between the top metal layer 3 and the discontinuous metal layer 4 ends at the transition 12, where the space between the corresponding metal layers is filled by the bonding agent 11.

The sets 10 comprising the continuous fiber-reinforced plastic layers 6, 7 are continuous, while the series 1 also includes the discontinuous fiber-reinforced plastic layers 9.

In the variant shown in Figure 7, a set 5 comprising three continuous fiber-reinforced plastic layers 6, 7, 8 is provided in the series 1. A set 10 comprising the two

continuous plastic layers 10 and a set 5 comprising the continuous plastic layer 8 and the discontinuous plastic layers 9 are provided in the series 2. The open spaces between the plastic bonding layers and the metal layers are filled with the bonding agent 11.

As shown in the figures, in each case one of the outer metal layers may be straight in cross section, while the other outer metal layer has a step or change in thickness. Furthermore, the corresponding laminate may, for example, be curved with respect to an axis of curvature parallel to this cross section and/or may be straight in the direction perpendicular to the plane of the cross section.

All kinds of different products can be selected for the metals and plastics. Examples of suitable metals are aluminum alloys, steel alloys, titanium alloys, copper alloys, magnesium alloys. In particular, mention may be made of aluminum-copper alloys (AA 2000), aluminum manganese alloys (AA 3000), aluminum-magnesium alloy (AA 5000), aluminum-zinc alloys (AA 7000) and aluminum-magnesium-silicon alloys (AA 6000).

The aluminum-copper alloy (AA 2224), the aluminum-zinc alloy (AA 7075) and the aluminum-magnesium-silicon alloy (AA 6013) are particularly preferred. The same is true of AA 2X24-23 and AA 7X75-26. If a high resistance to erosion is desired, an AA 50525 alloy may be included in the laminate.

Examples of suitable thermosets are epoxy resins, unsaturated polyesters, vinyl esters and phenolic esters. Examples of suitable thermoplastics are polyarylates (PAR), polysulfones (PSO), polyether sulfones (PES), polyetherimides (PEI) or polyphenylene ethers (PEE), polyphenylene sulfide (PPS), polyamide-4,6, polyketone sulfide (PKS), polyether ketones (PEK), polyether ether ketone (PEKK) and polyether ketone ketone (PEKK).

The bonding plastic layer may be provided with a reinforcement in the form of continuous fibers, for example as is the case in the abovementioned materials Glare ® and ARALL ®. It is preferable to use S-2 glass or R-glass fibers, which each comprise approximately 58 - 69% by weight of SiO_2, 18 - 29 % by weight of Al_2O_3 and 7 - 19% by weight of MgO. E-glass fibers, comprising approximately 55% by weight of SiO_2, 15% by weight of Al_2O_3, 19% by weight of CaO, 7% by weight of B_2O_3 and 3% by weight of MgO, are also suitable. A suitable aramid fiber is produced from polyparaphenylene terephthalamide.

Claims

1. Laminate, comprising at least one series of metal layers (3, 4) and fiber-reinforced plastic layers (6-9) which are attached to one another, characterized in that at least two different series (1, 2) are provided, these series including a transition (12), and in that at the location of the transition (12) at least one of the internal layers (4, 9) is discontinuous and all the other layers (3, 6-8) are continuous.

2. The laminate as claimed in Claim 1, in which there is a change in the thickness of the laminate at the location of the transition between two different series (1, 2).

3. The laminate as claimed in Claim 1 or 2, in which one series (1) has a different number of layers (3, 4, 6-8) from another series (2).

4. The laminate as claimed in Claim 3, in which at least one of the metal layers (3, 4) is discontinuous.

5. The laminate as claimed in Claim 4, in which there is in each case one set (5) of at least two plastic layers (6, 8) between two adjacent metal layers (3), and the set (5) is split at the end of a discontinuous metal layer (4), in such a manner that the plastic layers (6-8) of this set are situated on either side of the discontinuous metal layer (4).

6. The laminate as claimed in Claim 5, in which sets (10) which have a different number of plastic layers (8, 9; 6, 7) from the sets (5) in the region (1) without a discontinuous metal layer (4) are located on either side of the discontinuous metal layer (4).

7. The laminate as claimed in Claim 6, in which one series (1) comprises three metal layers (3), between each of which there is a set (5) comprising three plastic layers (6-8), and another series (2) comprises four metal layers (3, 4), of which three layers (3) are continuous from the first region (1) and of which an intermediate metal layer (4) is discontinuous, between each of which four metal layers (3, 4) there are sets (10) comprising two plastic layers (6-8), of which the sets (10) of plastic layers (6-8) on

either side of the discontinuous metal layer (4) are formed by one discontinuous plastic layer (9) and three plastic layers (6-8), which have continued from the first series (1), of a first set (5) comprising three plastic layers (6-8), and the second set (5) of three plastic layers (6, 7, 9) having two plastic layers (6, 7) which are continued into the other series (2) and one discontinuous plastic layer (9) which is not continued into the other series (2) (Fig. 1).

8. The laminate as claimed in one of the preceding claims, in which at least one of the fiber-reinforced plastic layers (6-9) is discontinuous.

9. The laminate as claimed in Claim 8, in which there are four metal layers (3), between each of which a set (5) of two plastic layers (6, 7) extends in one series, while in another series (2) there are also discontinuous plastic layers (9), so as to form sets (10) comprising three plastic layers (6, 7, 9) (Fig. 2).

10. The laminate as claimed in Claim 1 or 2, in which each series (1, 2) has the same number of layers (3, 4, 6-8), and the structure differs between the series (1, 2).

11. The laminate as claimed in one of the preceding claims, in which at least one layer comprising a bonding agent (11) without fiber reinforcement is provided (Fig. 5).

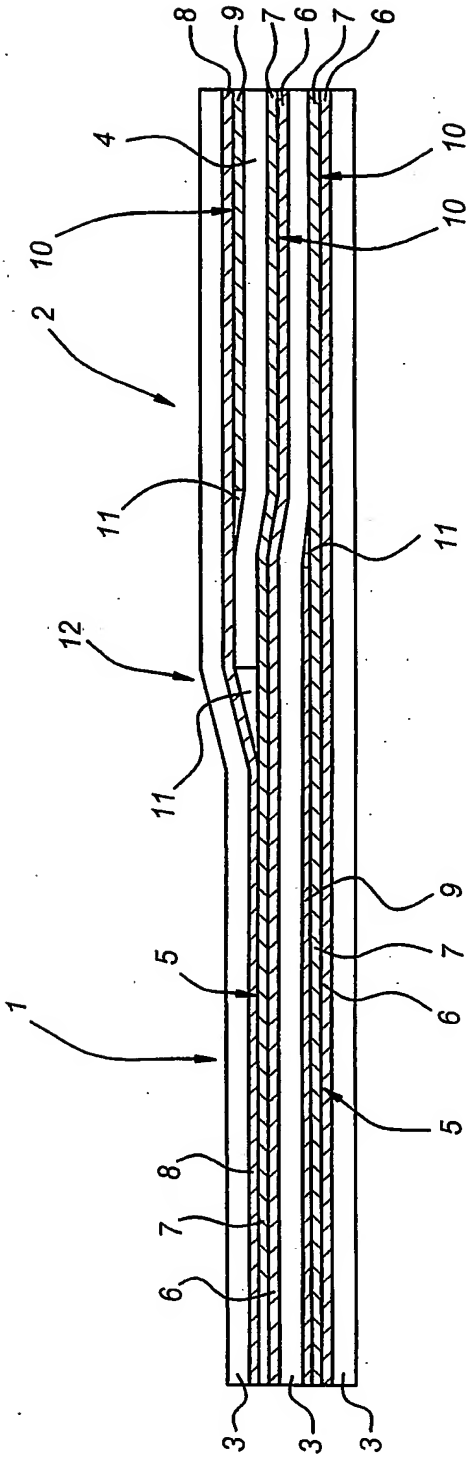
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Fig 1

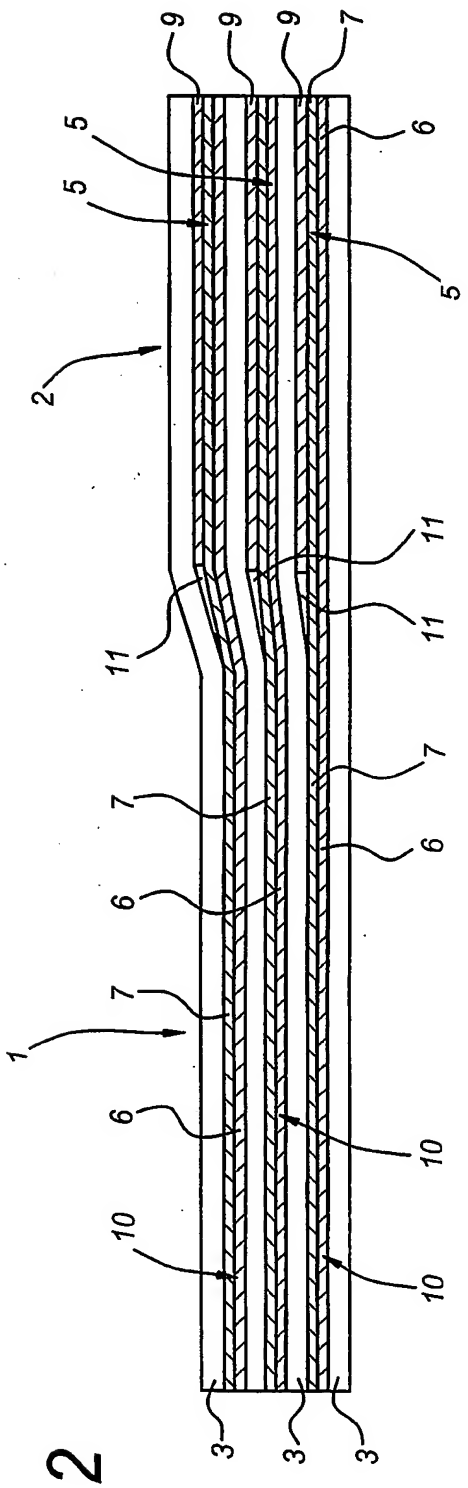
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Fig 2

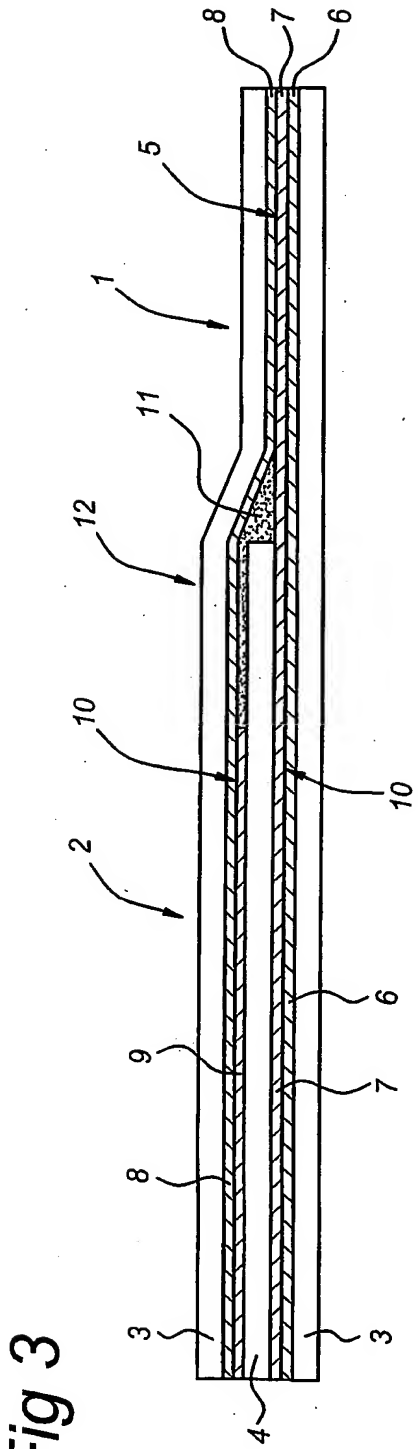

Fig 3

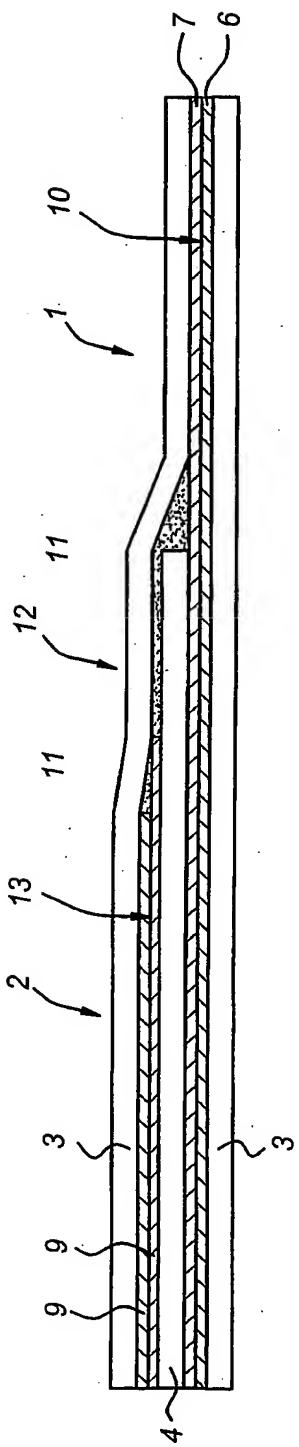

Fig 4

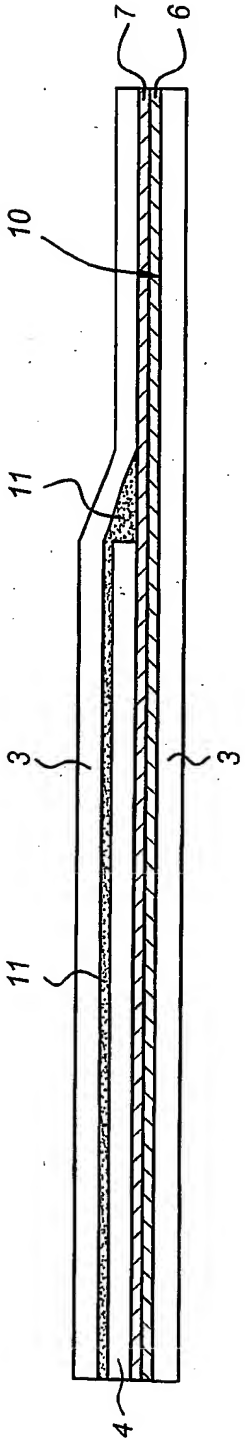

Fig 5

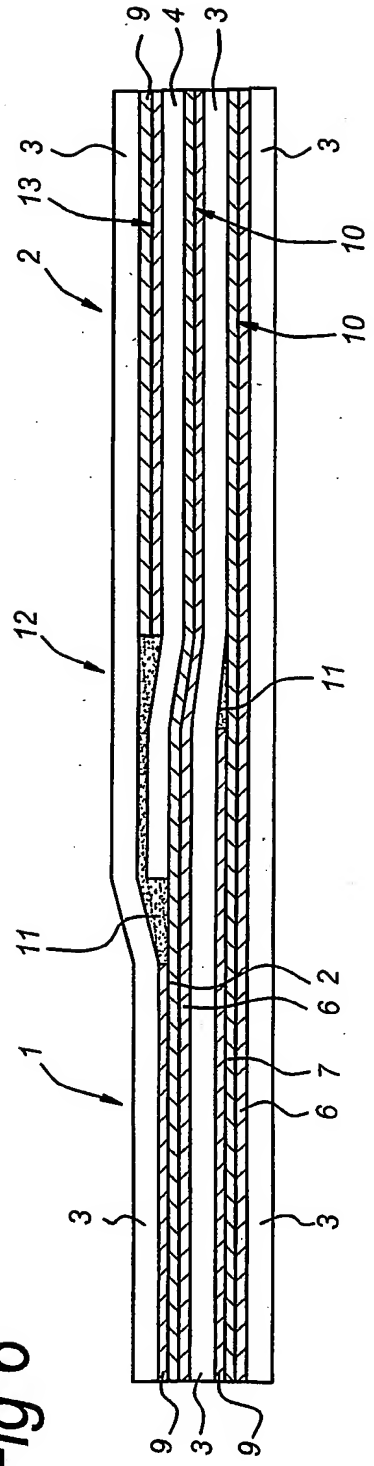

Fig 6

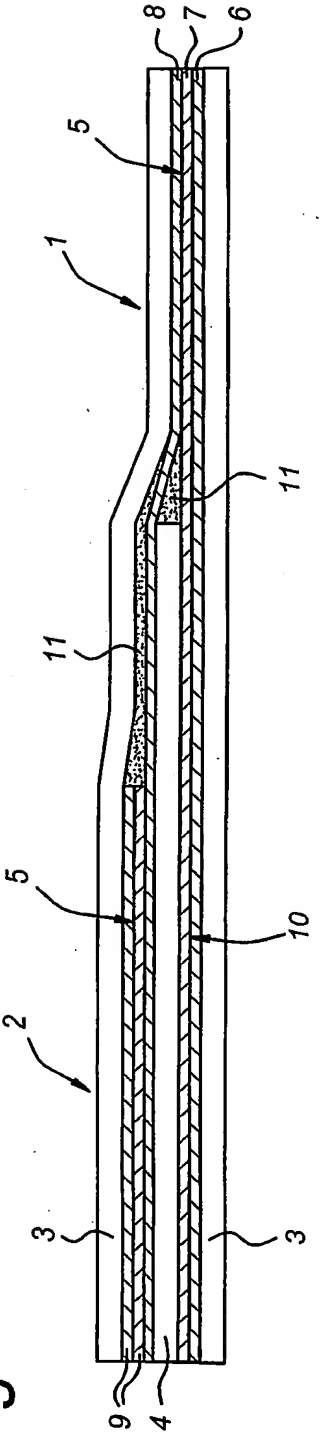

Fig 7

INTERNATIONAL SEARCH REPORT

Intern: Application No
PCT/NL 03/00105

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B32B3/10 B32B15/14

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B32B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 98 53989 A (AKZO NOBEL NV ;ROEBROEKS GERARDUS HUBERTUS JO (NL)) 3 December 1998 (1998-12-03)	1-3,10, 11
Y	claims; figures page 2, line 4 - line 12	1-11
Y	NL 1 015 141 C (FOKKER AEROSTRUCTURES B V) 13 November 2001 (2001-11-13) the whole document	1-11
X	US 5 417 385 A (ARNOLD MICHAEL J ET AL) 23 May 1995 (1995-05-23) claims; figure 11 column 3, line 42 -column 5, line 49	1-11

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

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"P" document published prior to the international filing date but later than the priority date claimed

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
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Date of the actual completion of the international search	Date of mailing of the international search report
22 May 2003	30/05/2003

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Ibarrola Torres, O

INTERNATIONAL SEARCH REPORT

Intern. Application No
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